



# Joint analysis of celestial pole offset and free core nutation series

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**Abstract** Three combined celestial pole offset (CPO) series computed at the Paris Observatory (C04), the United States Naval Observatory (USNO), and the International VLBI Service for Geodesy and Astrometry (IVS), as well as six free core nutation (FCN) models, were compared from different perspectives, such as stochastic and systematic differences, and FCN amplitude and phase variations. The differences between the C04 and IVS CPO series were mostly stochastic, whereas a low-frequency bias at the level of several tens of  $\mu\text{as}$  was found between the C04 and USNO CPO series. The stochastic differences between the C04 and USNO series became considerably smaller when computed at the IVS epochs, which can indicate possible problems with the interpolation of the IVS data at the midnight epochs during the computation of the C04 and USNO series. The comparison of the FCN series showed that the series computed with similar window widths of 1.1–1.2 years were close to one another at a level of 10–20  $\mu\text{as}$ , whereas the differences between these series and the series computed with a larger window width of 4 and 7 years reached 100  $\mu\text{as}$ . The dependence of the FCN model on the underlying CPO series was investigated. The RMS differences between the FCN models derived from the C04, USNO, and IVS CPO series were at a level of approximately 15  $\mu\text{as}$ , which was considerably smaller than the differences among the CPO series. The analysis of the differences between the IVS, C04, and USNO CPO series suggested that the IVS series would be preferable for both precession-nutation and FCN-related studies.

**Keywords** Earth orientation parameters (EOP) · Celestial pole offset (CPO) · Free core nutation (FCN) · Very long baseline interferometry (VLBI) · International VLBI Service for Geodesy and Astrometry (IVS) · International Earth Rotation and Reference Systems Service (IERS)

## 1 Introduction

The highly accurate observations of the motion of the Earth's axis in space is a unique capability of very long baseline interferometry (VLBI). The prevailing part of this motion is described using the conventional precession-nutation model IAU2000/2006 (Mathews et al. 2002; Capitaine et al. 2003; Petit and Luzum 2010), with a relatively small contribution of other terms primarily caused by unmodeled geophysical processes. In practice, VLBI observations provide the differences between the actual coordinates  $X$  and  $Y$  of the celestial pole in the celestial reference frame and those predicted by the IAU model. These differences are called celestial pole offset (CPO) and are designated as  $dX$  and  $dY$ . Their value is mostly below 1 mas. CPO consists of several terms:

$$\text{CPO} = \text{FCN} + T + P + S + N, \quad (1)$$

where FCN is the free core nutation;  $T$  is a sum of the trend components (low-frequency irregular variations), caused by, e. g., the inaccuracy of the conventional precession model, unmodelled source motions, and meteorological factors;  $P$  is a sum of the harmonic terms, caused, e. g., by the inaccuracy of the IAU nutation model;  $S$  is a sum of the systematic errors; and  $N$  is the measurement noise. The sum of the non-FCN terms is of the same order as that of the FCN terms. Meanwhile, the separation and analysis of the FCN contribution is

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